A SPATIAL MODEL OF REGIONAL VARIATIONS IN EMPLOYMENT GROWTH IN APPALACHIA

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Abstract: *In this study, a spatial equilibrium model of employment growth is developed and empirically estimated by Generalized Spatial Two-Stage Least Squares (GS2SLS) estimator using cross-sectional data from Appalachian counties for 1990-2000. Besides the existence of spatial spillover effects, the results suggest that agglomerative effects that arise from the demand and the supply side contribute to employment growth in the study area during the study period. The policy implications of the findings are: (1) Regional cooperation of counties and communities is advisable and may in fact be necessary to design effective policies to encourage employment growth; and (2) Policy makers at the county level may need to design policies that can attract people with high endowments of human capital and higher income into their respective counties.*

Key-words : APPALACHIA, EMPLOYMENT GROWTH, SPATIAL MODEL

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1. INTRODUCTION

Confronted with rising concerns about unemployment, job creation, economic growth and international competitiveness in global markets, policy makers at local, state, and national levels have responded with a new mandate to promote the creation of new businesses (Reynolds, 2000). The distribution of employment opportunities and the general economic health of a region depend on the distribution and nature of businesses that create jobs. Compared to the rest of the U. S. economy, Appalachia has lower establishment formation and attrition rates, as well as lower job creation and destruction rates in the 1990s. A study by Brandow (2001) shows that while retaining existing firms, Appalachia remains caught in a cycle of low levels of entrepreneurship, low growth among existing firms, and over-reliance on branch activities. Both the availability as well as the quality of jobs were lower. Wages, measured by the average paid at the establishment, were about 10 percent lower in Appalachia than in the rest of the nation (Foster, 2003). The region also continues to be a destination for low-income populations with relatively little education, and low-occupational status, while many of those with higher incomes, more education, and higher job status moved out during the second half of the 1990s (Obermiller and Howe, 2004). Thus, after a decade of unprecedented expansion of the economy of the United States, Appalachia still suffered from high unemployment, a shrinking economic base, deeply rooted poverty, low human capital formation, and out-migration (Haynes, 1997).

There is considerable regional variation within Appalachia with respect to the distribution of employment (*Figures 1 and 2*). The maps indicate that most of the employment is concentrated in Northern Appalachia, mainly in Appalachian Pennsylvania and New York, and in parts of Southern Appalachia. In contrast, the distribution of employment in Central Appalachia, in the southwest parts of Appalachian Mississippi and Alabama, and in West Virginia (northern Appalachia) is sparse. The majority of the distressed counties of Appalachia are clustered in these regions (see *Figure 4*). However, the pattern of employment growth shown in *Figure 3* indicates that regions with lower concentrations of employment in 1990 tend to grow employment at a faster rate than regions with higher concentrations. The fact that the distributions of employment in 1990 and in 2000 are similar, however, indicates that lagging regions of Appalachia did not catch up to the rest of Appalachia.

Despite national, state, and local programs to induce economic prosperity, many communities in Appalachia have failed to overcome poverty. Consequently, a better understanding of factors that influence local employment growth and quality of life issues is important from local, state and regional policy perspectives. To improve our understanding of the determinants of regional variations in growth, this paper investigates employment growth in Appalachia during the 1990s at the county level. Because counties are politically constructed geographical entities and are likely to exhibit interdependence in the form of spatial autocorrelation (Anselin, 1988, 2003), we examine variations in regional employment growth rates within the framework of a spatial autoregressive model with autoregressive disturbances.

Figure 1: Quintile Map of Employment Distribution in Appalachia, 1990, Number of Non-Farm Employment

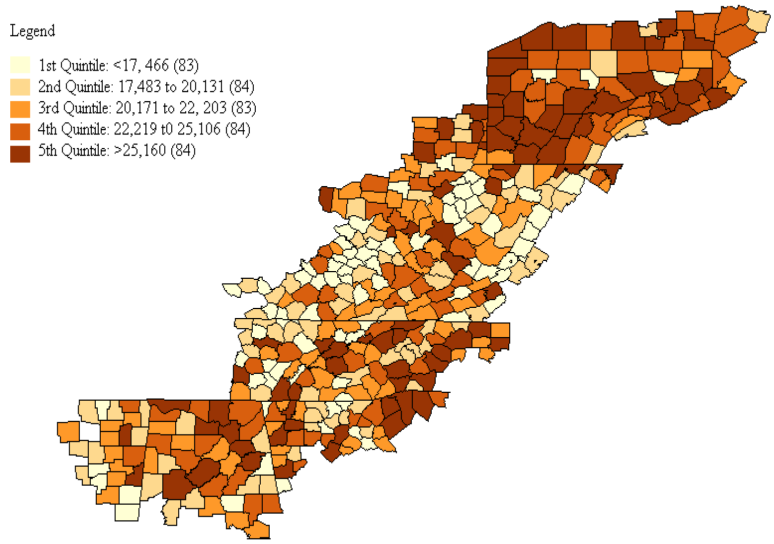


Figure 2: Quintile Map of Employment Distribution in Appalachia, 2000, Number of Non-Farm Employment

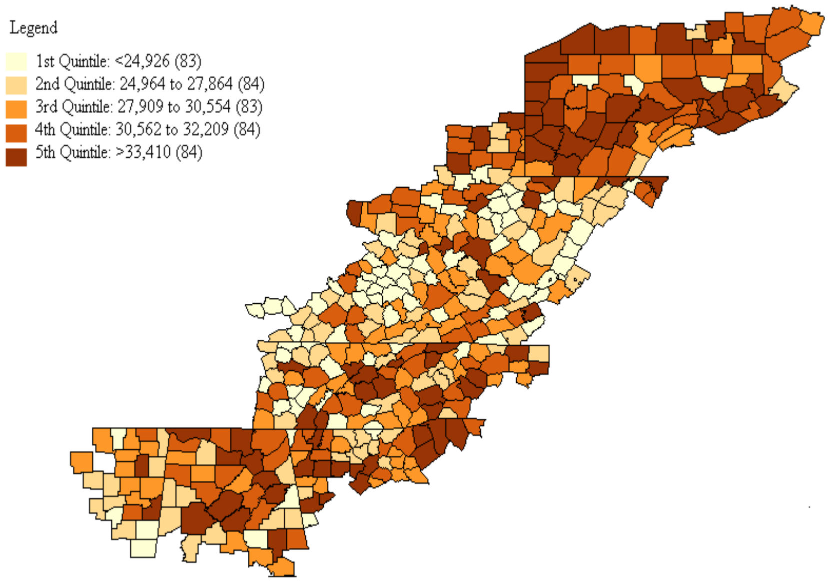


Figure 3: Quintile Map of Employment Growth Rates in Appalachia, 1990-2000

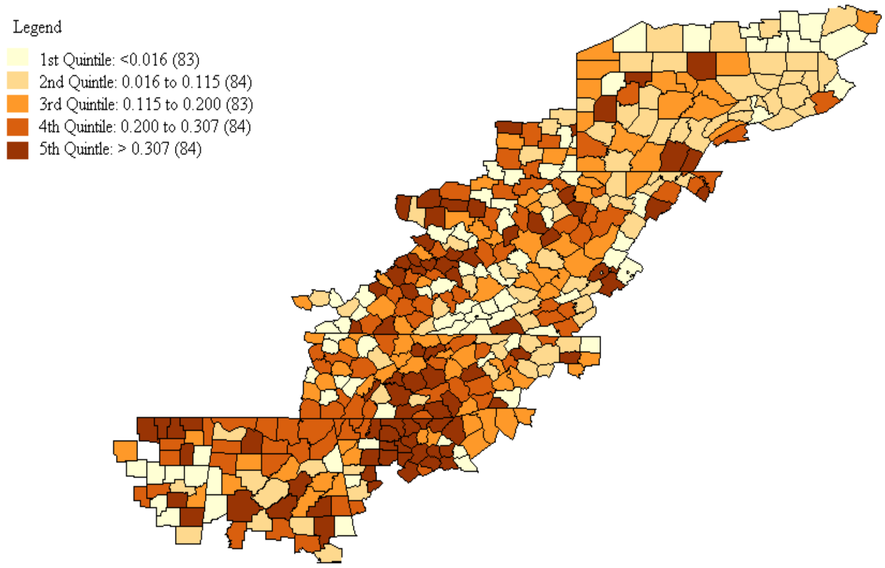
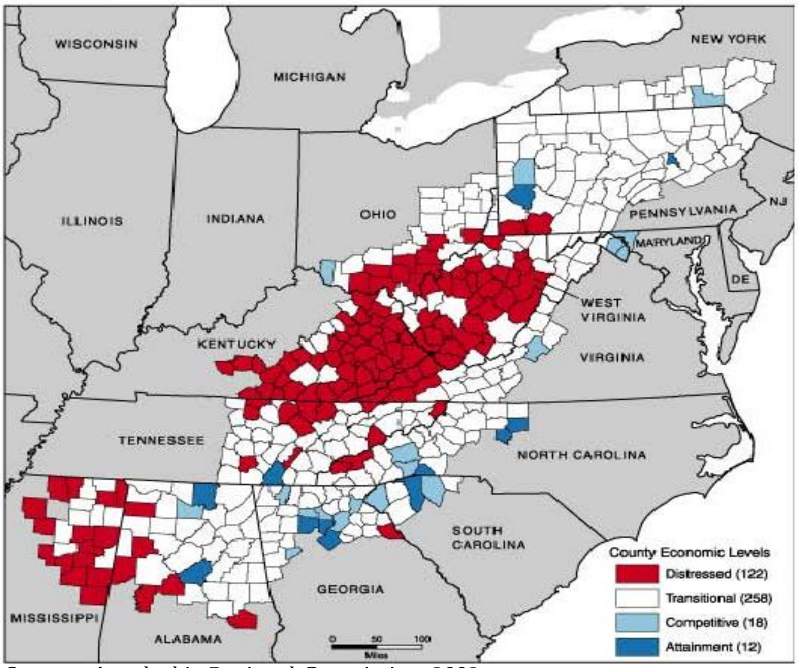


Figure 4: Economic Categories of Appalachia



Source : Appalachia Regional Commission, 2002.

The remainder of this study is organized into four sections. Section 2 presents the theoretical and empirical models, and definitions and descriptions of the data used. Section 3 discusses estimation issues. Section 4 presents the results. Finally, section 5 provides a short summary and conclusions.

2. MODEL DEVELOPMENT

2.1. Theoretical Model

Consistent with profit maximization, business firm location is assumed to be determined by demand and cost factors, including access to labor and output markets, local demand, the costs and availability of commercial land and labor, local taxes, and local public services. In addition, different locations are likely to have different characteristics that influence the costs of production. These include agglomeration economies associated with dense urban settlement, transportation costs, and site specific attributes. Following Carlton (1983), Friedman *et al.* (1992), Guimaraes *et al.* (2000), and Gabe and Bell (2004), the expected profit, π_{jk} , earned by business firm j in county k is given by:

$$\pi_{j,k} = \boldsymbol{\beta}'\boldsymbol{\Psi}_{j,k} + e_{j,k} \tag{1}$$

$\boldsymbol{\beta}$ is a vector of parameters, $\boldsymbol{\Psi}_{j,k}$ a vector of county-specific attributes, and e_{jk} a random error term. Profit maximization assumes that business firm j will locate in county k if the expected profits in county k are greater than the expected profits elsewhere. That is,

$$\pi_{j,k} > \pi_{j,l}, \quad \text{for all } l \neq k$$

In equilibrium, no firm can improve its profits by moving. Thus, equilibrium requires that profits be equalized at some level π^* across all locations,

$$\pi_{j,k} = \pi^*, \qquad \text{for all k}$$

For each firm, the profit function is defined by the following expression:

$$\pi_k = p_k Q_k - \sum_{i=1}^{n} w_{i,k} x_{i,k} \ , \tag{2}$$

where π_k is the profit at k, p_k the tax inclusive price of output at k, Q_k quantity sold at k, $w_{i,k}$ a vector of tax inclusive input prices at k, and x_{ik} a vector of inputs at k. Using a cost function for the production of Q and the first-order profit maximization conditions, $\pi_k = p_k Q_k - \sum_{i=1}^{n} w_{i,k} x_{i,k}$ can be rewritten as:

$$\pi_k = \pi\left(p_k, w_{i,k}, CA_k\right) \tag{3}$$

CA_k is a vector of other covariates that affect profits at k; the other notations are as defined above. Note that the cost factors include the wage rate; hence differentiating with respect to the wage rate yields the business firm's demand for labor. Thus, labor demand at location k by firm j can be written as:

$$EMP_{j,k} = EMP\left(p_k, w_{i,k}, CA_k\right) \tag{4}$$

$EMP_{j,k}$ is the employment level at location k by firm j, and the other notations are as defined above.

In a comparative static framework, the percentage change in employment is related to changes in the right-hand side variables as the system moves from one to another equilibrium position. The level of employment is at equilibrium ($EMP^*_{j,k}$) when firm j's profit at location k is in equilibrium (i.e., $\pi_{j,k} = \pi^*$).

Observed employment expansion consists of individual business firm decisions summed over all newly locating and expanding firms. Thus, the equilibrium level of employment at location k, EMP^*_k, depends on access to labor and output markets, local demand, the cost and availability of commercial land and labor, local taxes, and local public services. A log-linear specification of the equilibrium condition can be expressed as:

$$\mathbf{EMPR}_{kt} = \sum_{r=1}^{R} x_r \ln \mathbf{X}_{rkt} - \eta \ln \mathbf{EMP}_{kt-1}, \tag{5}$$

where $\mathbf{EMPR}_{kt}$ is the growth rate in employment ($\ln\left(\mathbf{EMP}_{kt}\right) - \ln\left(\mathbf{EMP}_{kt-1}\right)$), $x_r, r = 1,...R$ are exponents with R being the total number of variables included in vector $\mathbf{X}$. $\mathbf{X}$ is a vector of right-hand side exogenous variables, η the speed of adjustment parameter, and $\mathbf{EMP}_{kt-1}$ is the employment level in the base period.

2.2. Data and Empirical Model

This study uses data from 1990 and 2000 for Appalachian counties taken from County Business Patterns, Bureau of Economic Analysis, Bureau of Labor Statistics, Current Population Survey Reports, County and City Data Book, U.S. Census of Population and Housing, U.S. Small Business Administration, and Department of Employment Security. The dependent variable used in the empirical analysis includes the growth rate of employment (EMPR). The growth rate of employment is measured by the log-difference between the 2000 and the 1990 levels of private non-farm employment. The independent variables include demographic, human capital, labor market, housing, industry structure, amenity, and policy variables. In line with the literature, unless otherwise indicated, the initial values of the independent variable are used in the analysis.[1] This type of formulation also reduces the problem of endogeneity. All the independent variables are in log form except those that can take negative or zero values. The descriptions of each of the independent variables of the models are given in Table 1A.

The model to be estimated is:

$$\begin{aligned} EPMR = {} & \beta_1 + \beta_2 POP25-44 + \beta_3 POPCD + \beta_4 FHHF + \beta_5 UNEMP + \beta_6 MANU + \beta_7 WHRT \\ & + \beta_8 PCPTAX + \beta_9 NAIX + \beta_{10} HWD + \beta_{11} ESBd + \beta_{12} OWHU + \beta_{13} INM + \beta_{15} OTM \\ & + \beta_{16} MHY + \beta_{17} GEX + \beta_{18} EMP_1 + \varepsilon \end{aligned} \tag{6}$$

The percentage of the population 25 to 44 years of age (POP25-44) controls for supply and demand agglomeration effects. This variable is expected to have positive impacts on employment growth since a growing population increases the demand for consumer goods and services, as well as the pool of potential entrepreneurs, which encourages business formation and employment growth (Acs and Armington, 2004b). Human capital is measured as the percentage of adults (over 25 years old) with college degrees and above (POPCD). It is expected that educational attainment is positively associated with employment growth because better-educated people have better employment prospects and more human capital for implementing ideas for creating and growing new businesses and employment (Acs and Armington, 2004b).

The proportion of female-headed household families (FHHF) variable controls for the effect of local labor market characteristics on employment. It is expected to have negative impacts on employment growth since female householder families tend to have a lower labor participation rate. The county unemployment rate (UNEMP) variable measures the extent of local economic distress. Although a high county unemployment rate is normally associated with a poor economic environment, it may provide an incentive for individuals to form new businesses that can employ not only the owners, but also others. Thus, we do not know *a priori* whether the impact of UNEMP on employment growth is positive or negative.

The percentage of people employed in manufacturing (MANU) and the percentage of people employed in wholesale and retail trade (WHRT) variables capture the influence of sectoral employment concentration on the overall employment growth rate. Counties specializing in growing industries such as manufacturing and services are expected to have higher overall employment growth rates than counties specializing in declining industries such as mining and agriculture. During most of the study period, Appalachia has experienced a shift

[1] Data on income variables in the 1990 Census are for 1989 and data on taxes and government expenditure variables are from U.S. Census of Government 1992. U.S. Census of Government is conducted every five years and the nearest one to the 1990 is the 1992 U.S. Census of Government.

from coal-based economic activities to manufacturing and even more to services. Thus, the signs of both MANU and WHRT are expected to be positive.

Table 1A: Variable Description and Data Sources

Variable Code	Variable Description	Source
Endogenous Variable		
EMPR	Growth Rate of Employment, 2000-1990	Computed
Spatially lagged Endogenous Variable		
WEMPR	Spatial Lag of EMPR	Computed
Regional and Policy Variables		
POP25-44	Percent of population between 25 -44 years old, 1980, 1990	U.S. Bureau of the Census
FHHF	Percent of Female Householder, Family Householder, 1980, 1990	County & City Data Book
POPCD	Persons 25 years and over, % bachelor's degree or above, 1990	County & City Data Book
OWHU	Owner-Occupied Housing Unit in percent,1990	U.S. Bureau of the Census
UNEMP	Unemployment Rate, 1990	Bureau of Labor Statistics
MANU	Percent employed in manufacturing, 1990	County & City Data Book
WHRT	Percent employed in wholesale and retail trade, 1990	County & City Data Book
PCPTAX	Property Tax per Capita,1992	County & City Data Book
NAIX	Natural Amenities Index, 1990	USDA
HWD	Highway Density, 1990	US Highway Authority
ESBd	Establishment Density,1990	County Business Pattern
INM	In-migration,1990	Internal Revenue Service
OTM	Out-migration, 1990	Internal Revenue Service
MHY	Median Household Income, 1989	Bureau of Economic Analysis
GEX	Local Public Expenditures per Capita,1992	U.S. Bureau of the Census
EMP_1	Employment,1990	County & City Data Book

The per capita property income tax (PCPTAX) has both direct cost and input mix effects, which have opposing effects on employment and business expansion. Property tax could be levied on land or capital or both. The direct cost effect on location decision is negative. Once location is determined, the input mix effect could, however, be in the opposite direction. An increase in property tax on capital could push existing firms towards land and labor-intensive industries, expanding employment opportunities. Similarly, an increase in property tax on land could push existing firms towards capital and labor-intensive industries, again, expanding employment opportunities. Thus, *a priori*, the impact of property tax on business growth and employment creation is at best ambiguous.

Table 1B: Descriptive Statistics for Appalachian Counties, 1990-2000

Variable	Variable Description	Mean	Std Dev	Minimum	Maximum
EMPR	Growth Rate of Employment,1990-2000	0.1767	0.2450	-0.6945	1.7868
WEMPR	Spatial Lag of EMPR	0.1763	0.1301	-0.1298	0.8438
POP25-44	Percent of population between 25-44 years old, 1990	3.3799	0.0775	2.7850	3.7448
FHHF	Percent of Female Householder, Family Householder,1990	2.3219	0.2031	1.8114	3.1879
POPCD	Persons 25 years and over, % bachelor's degree or above,1990	2.2694	0.4065	1.3083	3.7305
OWHU	Owner-Occupied Housing Unit in percent,1990	4.3252	0.0761	3.8670	4.4728
UNEMP	Unemployment Rate,1990	2.1536	0.3482	1.2238	3.2465
MANU	Percent employed in manufacturing,1990	26.2402	11.2956	2.2000	53.6000
WHRT	Percent employed in wholesale and retail trade,1990	18.8278	3.5320	8.7000	27.7000
PCPTAX	Property Tax per Capita,1992	5.5236	0.6160	3.9120	7.3627
NAIX	Natural Amenities Index, 1990	0.1433	1.1587	-3.7200	3.5500
HWD	Highway Density, 1990	0.6904	0.4041	-0.3391	2.6319
ESBd	Establishment Density,1990	2.5255	0.3043	1.4929	3.6050
INM	In-migration,1990	7.0876	1.0019	4.5433	10.5199
OTM	Out-migration, 1990	7.0377	0.9755	4.4998	10.5495
MHY	Median Household Income, 1989	2.8684	0.3984	1.3863	3.9532
GEX	Local Public Expenditures per Capita,1992	7.2258	0.2795	6.4922	8.1083
EMP_1	Employment,1990	8.8265	1.2543	5.4205	13.3813

Note: All variables except NAIX are in log form.

The natural amenities index (NAIX) captures the impact of natural amenity on employment growth and it is expected to have positive effects because amenity rich counties are more favorable for business expansion and employment growth. Highway density (HWD) captures the influence of accessibility on business expansion and employment growth. Infrastructure connects people in underdeveloped and remote areas to core economies, thus expanding their employment opportunities (Estache, 2003). Moreover, a decrease in transportation cost between regions tends to encourage both agglomeration and the growth of activities for the whole economy; the growth effect goes through the impact of geography and the agglomeration effect goes through the impact on growth (Martin and Ottaviano, 1999, 2001). Since the seminal work of Krugman (1991), research in new economic geography (NEG) has grown at a fast pace (see, for example, Krugman and Venables, 1995; Fujita *et al*. 1999; Martin and Ottaviano, 1999, 2001; Fujita and Thisse, 2002, 2003, 2006; Fujita and Mori, 2005; Yamamoto, 2003; Baldwin and Martin, 2004). Two main insights of NEG on the relations between infrastructure, economic growth and agglomeration have also recently evolved. First, there is a trade-off between growth and regional equality because both agglomeration and growth are fostered by improved infrastructure in core regions, but hampered by improved infrastructure in remote regions. Second, since improved transport and communication infrastructure between core and peripheral regions fosters not only growth but also agglomeration, better interregional connections may lead to firm relocation and hence to less employment in poor/remote areas. Increased agglomeration, however, does not necessarily lead to impoverishment of remote areas provided that its positive effect on growth is strong enough (Fujita and Thisse, 2003).Thus, *a priori*, the sign of HWD is ambiguous.

Establishment density (ESBd), which is the total number of private sector establishments in the county divided by the county's population, captures the degree of competition among firms and crowding of businesses relative to population size. A higher establishment density may increase competition among firms for consumer demand and crowd out businesses, thereby decreasing employment. Conversely, a higher establishment density may be associated with employment growth because firms tend to locate near each other, possibly due to localization and agglomeration economies of scale. Thus, *a priori*, the impact of establishment density on employment growth is ambiguous. Owner occupied housing (OWHU) captures the effects of the availability of resources to finance businesses and create jobs on employment growth in the county. The percentage of owner-occupied dwellings is expected to be positively associated with employment growth in the county because homes may be used as collateral for loans to start new business that create jobs (Reynolds, 1994). A higher percentage of homes owned by their occupants may also indicate a capacity to finance new businesses by potential entrepreneurs. It could also signal demand for new jobs at a regional level.

Gross in-migration (INM) and gross out-migration (OTM) variables capture the impacts of population movements on employment growth. In-migration tends to shift the labor supply and labor demand curves right-wards, and out-migration tends to lead to leftward shifts of the curves. Thus, in-migration leads to increases in employment, whereas out-migration leads to decreases. A growing population increases the demand for consumer goods and services and is positively related to business formation and employment growth (Acs and Armington, 2004a). Median household income (MHY) captures the influence of income on employment growth and is expected to have a positive impact. Increases in the demand for goods and services that result from increases in family median or per capita income are associated with increases in employment (Armington and Acs, 2002).[2] Local government expenditures per capita (GEX) capture the impacts of public services on employment growth and are expected

[2] As suggested by one reviewer, we tried including a variable for real wages in our regression but our results showed an insignificant t value for the wage variable. We suspected this was due to multicollinearity. A correlation analysis confirmed that the wage variable and the Median Household Income variable are highly correlated, with a simple correlation coefficient of 0.85, so the real wages variable was dropped.

to have a positive impact. Public services such as education, highways, public safety, sewer and, water treatment services can be viewed as unpaid inputs in the production process of private businesses that contribute to output. Gabe and Bell (2004), for example, find that local public spending has positive and statistically significant effects on business location and employment growth.

The initial level of employment (EMP_1) captures the extent of conditional convergence in the system, with a negative and statistically significant coefficient for $\mathbf{EMP_1}$ indicating the existence of conditional convergence (Boarnet, 1994; Edmiston, 2004). Table 1A provides the full list of the endogenous and control variables, their descriptions, and the sources of the data.

2.3. Spatial Data Model

When data include a location component, spatial dependence between observations at each point in time and spatial heterogeneity, such as parameter variation with location, may arise (Elhorst, 2003). Regional factors that affect firms' location decisions are then more likely to exhibit spatial autocorrelation. Spatial dependence refers to the statistical property where the observations at one location depend on the values of observations at other locations (Anselin, 1988, 2003). There are two possible sources of spatial autocorrelation – lag dependence, which reflects true spatial interaction of variables across spatial units (e.g. spillovers from geographic proximities) and error dependence, which reflects the fact that sub-regions, such as counties, are artificial constructs that do not coincide with the real spatial extent of the variable of interest (e.g. employment growth rate). Accordingly, spatial dependence may be incorporated into the model as spatially lagged dependent variable (spatial lag model) or as spatial error autocorrelation (spatial error model). When spatial dependence is present in the dependent variable, it is interpreted as substantive spatial dependence and implies that the employment growth rate in one county depends on the employment growth rate in neighboring counties. This specification is based on an economic model in which the sources of spatial dependence are explicitly modeled (see, for example, Anselin, 2006; Fingleton and Lopez-Bazo, 2006). When spatial dependence is present in the disturbance term, it implies that the residuals in one county depend on the residuals in neighboring counties. This process is interpreted as nuisance spatial dependence. Unlike spatial lag models, the spatial error specifications are not motivated by a theoretical economic model, but instead are formulated to deal with correlation problems that result from the cross-sectional nature of the data and not necessarily from the spatial nature of the model (Anselin, 2006).

In the presence of spatial dependence, estimation of the model requires us to determine which counties are neighbors. The neighborhood set for each observation is specified through an $N \times N$ spatial weights matrix, **W**. The main diagonal elements of **W** are zeros and its off-diagonal elements, $\boldsymbol{w_{k,l}}$, represent neighbor relations (spatial relationship) between observation k and l. There is very little formal guidance in the choice of the correct spatial weights for a given model specification (Anselin, 2006). A common method of forming **W** is to define neighbors on some geographic criteria, such as polygons having a common boundary (contiguity) or points being within a critical distance band.[3] That is:

$$w_{kl} = \begin{cases} 1 & \text{if k and l (k} \neq \text{l) have common boundary} \\ 0 & \text{otherwise} \end{cases}$$

for the contiguity weights matrix, and

$$w_{kl} = \begin{cases} 1 & \text{if } d_{kl} \leq \bar{d} \text{ where } \bar{d} \text{ is a threshold value} \\ 0 & \text{otherwise} \end{cases}$$

for distance-based weights matrix. Row-normalized versions of these weights matrices are used in our empirical model. Based on the pattern of inter-county movement in Appalachia, we chose the cut-off distance ($\bar{d}$) to be 28 miles. The average commuting time in Appalachian states is around 25 minutes (one way) which is equivalent to 28 miles (U.S. Census Bureau 2005).[4]

Table 2: Diagnostics for Spatial Dependence

	Contiguity Spatial Weights			**Distance-Based Spatial Weights**		
Test	**MI/DF**	**Value**	**Prob.**	**MI/DF**	**Value**	**Prob.**
Moran's I (error)	0.05227	3.16403	0.001556	0.047874	2.339539	0.009308
Lagrange Multiplier(lag)	1	7.436946	0.00639	1	6.972609	0.008277
Robust LM (lag)	1	0.289822	0.590335	1	2.633556	0.104627
Lagrange Multiplier(error)	1	7.771184	0.005309	1	7.55883	0.003749
Robust LM (error)	1	0.624061	0.429542	1	0.219777	0.63921
Lagrange Multiplier(SARMA)	2	8.061006	0.017765	2	7.192386	0.027428

Tests for spatial dependences indicate the existence of spatial dependence in both the dependent variable and in the error term. The results are given in Table 2. The model given in equation (6) can thus be extended to account for these spatial interdependences as follows:

$$\mathbf{y} = \rho\mathbf{W}\mathbf{y} + \mathbf{X}\beta + \mathbf{u} \tag{7}$$

with

$$\mathbf{u} = \lambda\mathbf{W}\mathbf{u} + \boldsymbol{\varepsilon}$$

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[3] The most common choice of spatial weights in the empirical literature is the simple contiguity matrix followed by distanced-based weights (Abreu *et al*., 2005).
[4] Several cut-off distances between 15 and 40 were assessed, but the results were virtually insensitive to values in this range.

where **y** is an (*N x 1*) vector of county employment growth rates. **W** is *N x N* spatial weights matrix as described above. For a row standardized weights matrix, the spatially lagged employment growth rate variable (**Wy**) is the average of the employment growth rates in neighboring counties. **X** is (*N x R*) matrix of observations on the explanatory variables, ρ the spatial autoregressive parameter and measures the degree of spatial dependence inherent in the data. β is (*R x 1*) vector of regression coefficients. **u** is (*N x 1*) vector of error terms that are assumed to follow a spatial autoregressive process, and λ is the spatial autoregressive coefficient for the error lag **Wu**, and $\boldsymbol{\varepsilon}$ a (*N x 1*) vector of innovations or white noise error.

3. ESTIMATION ISSUES

Since the right-hand side spatial lag dependent variable (**Wy**) is correlated with the error term, Ordinary Least Squares (OLS) cannot give consistent estimates of the parameters of equation (7) as it stands. Thus, we estimate the parameters of the model using a generalized spatial two-stage least squares (GS2SLS) procedure following Kelejian and Prucha (1998). In order to define the GS2SLS estimator, we first rewrite equation (7) as follows:

$$\mathbf{y} = \mathbf{Z}\boldsymbol{\delta} + \mathbf{u} \tag{8}$$

with

$$\mathbf{u} = \lambda\mathbf{W}\mathbf{u} + \boldsymbol{\varepsilon}$$

$\mathbf{Z} = (\mathbf{X}, \mathbf{W}\mathbf{y})$ and $\boldsymbol{\delta} = (\boldsymbol{\beta}', \boldsymbol{\rho}')'$.The GS2SLS method identifies $\boldsymbol{\delta}$ by a moment condition which is the orthogonality between the set of instruments **H** and the error term **u** given by:

$$E(\mathbf{H}'\mathbf{u}) = \mathbf{0}, \tag{9}$$

where **H** is defined as a subset of the linearly independent columns of $(\mathbf{X}, \mathbf{W}\mathbf{X}, \mathbf{W}^2\mathbf{X})$. It is assumed that the elements of **H** are uniformly bounded in absolute value. **H** is a full column rank non-stochastic instrument matrix (see Kelejian and Prucha, 1998, for the description of its prosperities). The GS2SLS estimator is given by

$$\hat{\boldsymbol{\delta}} = \left(\bar{\mathbf{Z}}_{(\hat{\lambda})}'\bar{\mathbf{Z}}_{(\hat{\lambda})}\right)^{-1}\bar{\mathbf{Z}}_{(\hat{\lambda})}'\mathbf{y}_{(\hat{\lambda})} \tag{10}$$

$\bar{\mathbf{Z}}_{(\hat{\lambda})} = \mathbf{P}_H\left(\mathbf{Z} - \hat{\lambda}\mathbf{W}\mathbf{Z}\right), \mathbf{y}_{(\hat{\lambda})} = \mathbf{y} - \hat{\lambda}\mathbf{W}\mathbf{y}$ and $\mathbf{P}_{\mathrm{H}} = \mathbf{H}\left(\mathbf{H}'\mathbf{H}\right)^{-1}\mathbf{H}'$. This is the result of the third step in the three-step GS2SLS procedure suggested by Kelejian and Prucha. In the first step, the parameter vector $(\boldsymbol{\delta})$ consisting of betas and rho $[\beta', \rho']$ is estimated by two-stage least squares (2SLS), using the instrument matrix **H** that consists of a subset of $\mathbf{X}, \mathbf{WX}, \mathbf{W}^2\mathbf{X}$. The disturbance term in the model is computed by using the estimates for betas and rho (ρ) from the first step. In the second step, this estimated disturbance term is used to obtain the autoregressive parameter lambda (λ), using Kelejian and Prucha's (1999) generalized moments procedure. In the third step, a Cochran-Orcutt-type transformation is done by using the estimate for lambda (λ) from the second step to account for the spatial autocorrelation in the disturbance. The generalized spatial two-stage least squares (GS2SLS) estimators for betas and rho (ρ) are then obtained by estimating the transformed model using $\left[\mathbf{X}, \mathbf{WX}, \mathbf{W}^2\mathbf{X}\right]$ as the instrument matrix as given in (10).

4. RESULTS AND DISCUSSION

The GS2SLS parameter estimates of the system given in (7) are reported in Table 3. The parameter estimates are mostly consistent with theoretical expectations.[5] The results suggest a positive and significant parameter estimate for rho that indicates that the employment growth rate tends to spillover to neighboring counties and have a positive effect on their employment growth rates. This is important from a policy perspective as it indicates that employment growth in one county has positive spillover effects to EMPRs in neighboring counties. The result is also important from an economic perspective because this significant spatial lag effect indicates that EMPR does not only depend on characteristics within the county, but also on that of its neighbors. Hence, spatial effects should be tested for in empirical works involving employment growth rates. The model specification in this study also incorporates spatially autoregressive spatial process (effect) besides the spatial lag in the dependent variable. The results in Table 3 suggest a negative parameter estimate for lambda, indicating that random shocks into the system with respect to EMPR do not only affect the county where the shocks originated and its neighbors, but create negative shock waves across Appalachia.

The coefficient on POP25-44 is positive and statistically highly significant. The 25-44 year-old age groups include women in their prime childbearing years. Members of this group also tend to be better educated, attracted to urban areas, and are a source of entrepreneurial talent. The results show that POP25_44 has positive and significant total effect (*direct* plus *indirect* plus *induced effects*) on EMPR (see Appendix for details on the interpretations of the coefficients). This result is consistent with the literature (Acs and Armington, 2004a; Reynolds, 1994; Keeble *et al.*, 1992) which indicates that a growing population increases the demand for consumer goods and services, as well as the pool of potential entrepreneurs, which encourage business formation. This result is important from a policy perspective. It indicates that counties with high population concentrations are benefiting from the resulting agglomerative and

[5] Tests for multicollinearity show no presence of serious multicollinearity.

spillover effects that lead to localization of economic activities, in line with Krugman's (1991a, 1991b), Jaffe (1989), and Acs *et al.* (1992, 1994) arguments on regional spillover effects.

Table 3. Generalized Spatial Two-Stage Least Squares (GS2SLS) Estimation Results

Variable	Variable Description	Contiguity Spatial Weights		Distance-Based Spatial Weights	
		Coefficient	t-statistic	Coefficient	t-statistic
Constant		-2.55906***	-4.16271	-0.188970	-0.24970
WEMPR	Spatial Lag of EMPR	0.472478***	6.77779	0.115188***	3.01809
POP25-44	Percent of population between 2 -44 years old ,1990	0.578367***	5.27633	0.52412***	4.33092
POPCD	Persons 25 years and over, % bachelor's degree or above, 1990	0.178934***	6.20471	0.16548***	5.13155
FHHF	Percent of Female Householder, Family Householder, 1990	-0.081337*	-1.90338	-0.071890*	-1.96466
UNEMP	Unemployment Rate,1990	-0.064749**	-2.12652	-0.325740***	-3.45607
MANU	Percent employed in manufacturing, 1990	5.135E-03***	3.92878	0.00314494**	2.03237
WHRT	Percent employed in wholesale and retail trade,1990	0.012621**	2.35009	0.010665**	2.06131
PCPTAX	Property Tax per Capita,1992	-0.021163	-1.2753	-0.186890	-1.08621
NAIX	Natural Amenities Index, 1990	0.013990**	2.39444	0.0094147**	2.49610
HWD	Highway Density, 1990	0.050738***	2.86263	0.031575***	2.62944
ESBd	Establishment Density,1990	-0.249115***	-3.27372	-0.264153***	-3.07499
OWHU	Owner-Occupied Housing Unit in percent,1990	0.171958**	2.1671	0.183898**	2.18074
INM	In-migration,1990	0.051733**	2.06721	0.125851**	1.98639
OTM	Out-migration, 1990	-0.070708**	-2.28023	0.097721**	2.39379
MHY	Median Household Income, 1989	0.083978**	2.22004	0.200287***	2.82018
GEX	Local Public Expenditures per Capita,1992	2.89E-03	0.105793	0.032417	1.06916
EMP_1	Employment,1990	-0.095431***	-5.21372	-0.106039***	-5.50686
Lambda (λ)	Spatial Error Parameter	-0.27638***	-9.99976	-0.291770***	-11.4918
ETA (η)	Speed of Adjustment Parameter	0.095431		0.10604	
	Half-Life	73.3351		66.0134	
$NR^2 \sim \chi^2(20)$	Orthogonality test	48.461562	0.22852	46.8047	0.39826
n	Sample Size	418		418	

*Note: *, **, and *** denote statistical significance level at 10 percent, 5 percent and 1 percent, respectively.*

Consistent with theoretical expectations, the results also show that initial human capital endowment, measured by the percentage of adults (over 25 years old) with a college degree (POPCD), is positive and statistically significant at the one percent level. Highly educated people in most cases have better access to research and development facilities, and perhaps also better insights into the business world and clearer ideas about the needs of the market. As Christensen

(2000) contends, well educated entrepreneurs are also more likely to know how to transform innovative ideas into marketable products. Thus, people with more educational attainment tend to establish business, and to be more successful when they do, more often than those with lower educational attainments. This result is also consistent with Acs and Armington's (2004b) findings which indicate that agglomerative effects that contribute to new firm formation could come from the supply factors related to the quality of the local labor market and business climate. One possible implication of these findings is that regions or counties with different levels of human capital endowment and different propensities of locally available knowledge to spill over and stimulate new firm formation, tend to have different rates of new firm formation, survival, and growth (Armington and Acs, 2002; Guesnier,1994; Lloyd and Mason,1984; Cross, 1981). The coefficient on FHHF is negative and statistically significant at the ten percent level, indicating that FHHF has a negative impact on EMPR. This is consistent with theoretical expectations and empirical findings. FHHF affects both the supply-side (as source of labor input) and the demand-side (as source of demand for consumer goods). Thus, this result suggests that Appalachian counties with a higher proportion of female household heads in their communities tend to show lower growth in business or employment.

Our results suggest that a high unemployment rate is associated with low employment growth. This indicates that the poor economic environment in Appalachia failed to provide an incentive for individuals to form new businesses that can employ not only the owner, but others, as well. Unemployed individuals may not have the capital to start a business. A high level of unemployment is also an indication of a reduction in aggregate demand in the region, which puts downward pressure on new firm formation. This result is also in line with the study by Acs and Armington (2004b), who found that unemployment is associated negatively with new firm formation during growth periods and positively during recession periods, and with the studies by Storey and Jones (1987), Audretsch and Fritsch (1994), and Garofoli (1994).

The coefficient on MANU is positive and statistically significant at the one percent level, indicating a direct relationship between growth in overall employment or business expansion and manufacturing employment at the beginning of the periods. The coefficient on WHRT is also positive and significant at the five percent level, indicating the positive role played by the service sector in expanding employment and business in Appalachia during the study period. Thus, these results suggest that Appalachian counties who had a higher proportion of their labor force in manufacturing and wholesale and retail at the beginning the period, experienced higher growth rates in overall employment. This is not unrealistic because during most of the study period, many areas in Appalachia experienced a shift from coal mining-based economic activities to manufacturing and even more to services.

The coefficient of the natural amenity index (NAIX) is positive and statistically significant at the one percent level. This result is inconsistent with McGranahan (1999) who found a weaker overall association between natural amenities and employment change. The positive and statistically significant coefficient on HWD shows a positive association between the concentration of roads and employment growth. This result suggests that during the study period Appalachian counties with higher road densities experienced greater employment growth than counties with low road densities. This finding is consistent with both theory and empirical findings (Carlino and Mills, 1987, Estache, 2003).

The coefficient on ESBd is negative and statistically significant at the one percent level, indicating that Appalachia has reached the threshold where competition among firms for consumer demands crowds businesses. Thus, a high ESBd is associated with low Employment growth, indicating that firms tend not to locate near each other, possibly due to high competition for local demand.

The coefficient on the variable representing the percentage of owner-occupied homes (OWHU) is positive and significant at the one percent level. This indicates that high home ownership is positively associated with business formation. This is consistent with the theoretical expectation that high home ownership is an indication of the capacity to finance new business by potential entrepreneurs, either by using the house as collateral for a loan or as indication of availability of personal financial resources to start a new business. It also supports empirical findings in the literature (Reynolds, 1994; Keeble and Walker, 1994).

The results indicate that the county employment level is dependent on gross in-migration, gross out-migration, and median household income. The coefficient for INM is positive and significant at the five percent level. The coefficient for OTM is negative and statistically significant at the one percent level. These are consistent with theoretical expectations and empirical findings (Clark and Murphy, 1996; MacDonald, 1992; Borts and Stein, 1964). Consistent with theoretical expectations and empirical findings, the coefficient for MHY is positive and statistically significant at one percent level. Increases in the demand for goods and services that result from increases in family median or per capita income are associated with increases in employment (Armington and Acs, 2002; Wennekers *et al.*, 2002; Carree, *et al.*, 2002; Gaygisiz and Koksal, 2003).

An interesting observation from the results pertains to the role of local government on employment growth. Our model predicts that local governments, through their spending and taxation functions, have critical roles in creating enabling economic environments for businesses to prosper. The results of our model, however, indicate that local governments have not played significant roles in employment growth in Appalachia. Given the economic hardship and high level of underdevelopment in most areas in this region, these results indicate that local governments may need to step up their efforts to create incentives to encourage business and employment growth.

Finally, the elasticity of EMPR with respect to the initial employment level (EMP_1) is negative and statistically significant, indicating convergence in the sense that counties with low initial levels of employment tend to have higher rates of employment growth than counties with high initial levels of employment, conditional on the other explanatory variables in the model. This result supports prior results of rural renaissance in the literature (Deller *et al.*, 2001; Lunderberg, 2003). The speed of adjustment (η) is calculated as 0.09543. This indicates that about 9.543 percent of the equilibrium rate of employment growth was realized during the ten-year period 1990-2000. This is comparable to other results in the literature.

5. CONCLUSIONS

The main objective of this study was to investigate the determinants of regional variation in employment growth rates in Appalachian counties. To do this, a spatial growth equilibrium model was developed and empirically estimated by Generalized Spatial Two-Stage Least Squares (GS2SLS) estimator, using county-level data covering all 418 Appalachian counties for the period 1990-2000. The parameter estimates are consistent with theoretical expectations and empirical findings in the equilibrium growth literature. In particular, we find that EMPR in one county is positively affected by EMPR in neighboring counties. The policy implication of this is that neighboring counties may need to pool their resources in order to create favorable business climate to make their counties attractive to firms. Our results also indicate the presence of spatial correlation in the error terms. This implies that a random shock into the system spreads across the region. The results also indicate convergence across counties in Appalachia with respect to EMPR conditional upon the initial conditions of the explanatory variables in the model. The speed of adjustment is relatively low, about one percent of the equilibrium rate of growth of employment is realized each year.

The results also indicate the presence of significant agglomerative effects. Counties that had populations with higher level of educational attainment and income at the beginning of the decade showed significant employment growth. This information may encourage policy makers at the county level to design policies that are attractive to people with these characteristics.

This study has dealt with *spatial dependence*, one of the two basic forms of spatial effects. The other one is *spatial heterogeneity*, whose presence leads to possible parameter variations across spatial units depending on their location. Testing for the presence of spatial heterogeneity in our data and the analyses of its impacts on parameter estimates, if present, is left for further research.

APPENDIX
Interpretations of the Coefficients of the Spatial Model

To interpret the coefficients of the spatial model, first the model given in (7) is expressed in its reduced form as follows:

$$\mathbf{y} = (I-\rho\mathbf{W})^{-1}\mathbf{X}\beta + \nu, \text{ with } \nu = (I-\rho\mathbf{W})^{-1}(I-\lambda\mathbf{W})^{-1}\boldsymbol{\varepsilon} \tag{11}$$

where $(I-\rho\mathbf{W})^{-1}$ is an N x N inverse matrix, ν is an N x 1 column vector and the other variables as defined in (7). Setting $A=(I-\rho\mathbf{W})^{-1}$, (11) can be written as:

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_N \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1N} \\ a_{21} & a_{22} & \cdots & a_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ a_{N1} & a_{N2} & \ldots & a_{NN} \end{bmatrix} . \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1N} \\ x_{21} & x_{22} & \cdots & x_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ x_{N1} & x_{N2} & \ldots & x_{NN} \end{bmatrix} . \begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_N \end{bmatrix} + \begin{bmatrix} \nu_1 \\ \nu_2 \\ \vdots \\ \nu_N \end{bmatrix} \tag{12}$$

Let us define $\mathbf{x}_R$ as a column vector (N x 1) of one of the explanatory variables, say the percentage of the population of 25 to 44 years of age (POP25-44). Then, the derivative of **y,** (N x 1) vector of employment growth rates with respect to $\mathbf{x}_R$' is defined as follows:

$$\frac{\delta y}{\delta x'_R} = \begin{bmatrix} \partial y_1/\partial x_{1R} & \partial y_1/\partial x_{2R} & \cdots & \partial y_1/\partial x_{NR} \\ \partial y_2/\partial x_{1R} & \partial y_2/\partial x_{2R} & \cdots & \partial y_2/\partial x_{NR} \\ \vdots & \vdots \ \ddots \ \vdots & \ddots & \vdots \\ \partial y_N/\partial x_{1R} & \partial y_N/\partial x_{2R} & \ldots & \partial y_N/\partial x_{NR} \end{bmatrix}. \tag{13}$$

This is the Jacobian matrix of **y** with respect to $\mathbf{x}_R$'. Thus, the marginal effect of an increase in $\mathbf{x}_R$' on **y** is derived as follows:

$$\frac{\delta y}{\delta x'_R} = \begin{bmatrix} \beta_R a_{11} & \beta_R a_{12} & \cdots & \beta_R a_{1N} \\ \beta_R a_{21} & \beta_R a_{22} & \cdots & \beta_R a_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \beta_R a_{N1} & \beta_R a_{N2} & \ldots & \beta_R a_{NN} \end{bmatrix} = \beta_R A = \beta_R (I-\rho\mathbf{W})^{-1}, \tag{14}$$

where $(I-\rho\mathbf{W})^{-1}$ is the spatial multiplier.

Since $|\rho| \le 1$, the marginal effect can be decomposed into various effects using the formula for a sum to infinity:

$$\begin{aligned} \beta_R (I-\rho\mathbf{W})^{-1} &= (I + \rho\mathbf{W} + \rho^2\mathbf{W}^2 + \rho^3\mathbf{W}^3 + \cdots)\beta_R \\ &= I\beta_R + \rho\mathbf{W}\beta_R + \rho^2\mathbf{W}^2\beta_R + \rho^3\mathbf{W}^3\beta_R + \cdots \end{aligned} \tag{15}$$

The total effect of a marginal change in any of the exogenous variables, say Pop25-44, on employment growth rate at location 'i', say county 1, is the sum of the direct effect, $\partial y_1 / \partial x_{1R}$, plus the indirect effect, $\partial y_1 / \partial x_{2R}$, plus the induced effect, $\sum_{i=3}^{N} \partial y_1 / \partial x_{iR}$. In terms of (15), the direct effects are on the diagonals of $I\beta_R$ and they represent the impacts of a marginal change in any of the exogenous variables in location 'i' on the employment growth in location 'i'. The indirect effects are on the off-diagonal positions of $\rho \mathbf{W} \beta_R$ and they are spillovers of the direct effects. Both the direct and the indirect effects are local in the sense that only the regions in which there has been an exogenous shock and their neighbors are affected. The induced effects which are represented by $\rho^2 \mathbf{W}^2 \beta_R + \rho^3 \mathbf{W}^3 \beta_R + \cdots$ are the results of spatial spillovers induced by the direct and indirect effects and they comprise impacts on the higher-order neighbors (neighbors of the neighbors of i) as well as feed-back effects on regions which are already experiencing direct and indirect effects Thus, the spatial effects in the model are global in nature (see Abreu et al. 2005; LeSage and Pace, 2009; Anselin and Le Gallo, 2006).

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UN MODÈLE SPATIAL DE CROISSANCE DE L'EMPLOI DANS LA RÉGION DES APPALACHES

Résumé - *Dans ce travail, nous développons un modèle d'équilibre spatial de croissance de l'emploi à travers un estimateur des moindres carrés généralisés en 2 étapes (GS2SLS) sur des données transversales des communes de la région des Appalaches entre 1990 et 2000. Outre l'existence d'effets de débordement spatial, les résultats montrent que les effets d'agglomération liés à l'offre et/ou à la demande localisées ont un rôle positif sur l'emploi. Plus particulièrement, on montre que : (1) la coopération régionale entre communes est souhaitable pour mener des politiques visant à stimuler la croissance de l'emploi, (2) les politiques locales en faveur de l'emploi doivent davantage chercher à attirer des travailleurs dotés d'un capital humain élevé.*